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Forest Insect Laboratory
Coeur d'Alene, Idaho

Archie L. Gibson

Project h-1-17 (2)

Date January 4, 1943

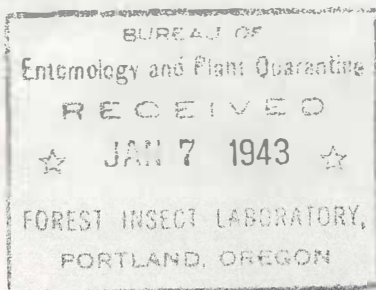
Author Assistant Entomologist

TITLE

SPRING CONTROL OF THE MOUNTAIN
PINE BEETLE IN WESTERN WHITE PINE
WITH PENETRATING SPRAYS
1942

SUBJECT-

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Noted by PLF

W.L.K.

J.M.W.

Forest Insect Laboratory
Coeur d'Alene, Idaho

January 5, 1943

To: F. C. Craighead, in Charge, Forest Insect Investigations

From: James C. Evenden, in Charge, Coeur d'Alene Laboratory

Subject: Mr. Gibson's report "Spring control of the mountain pine beetle in western white pine with penetrating sprays, 1942"

I am enclosing a copy of Mr. Gibson's report covering the results of spring control of the mountain pine beetle in western white pine with penetrating sprays. You will note that Mr. Gibson reports success with the use of a 1 to 12 mixture of orthene and Diesel oil. He also shows on page 8 very good success with a mixture of 15 to 1. However, as one tree showed very poor results, he dismissed the possibility of using this weak solution in favor of the 12 to 1, where the results obtained were constant. My reaction to these weak solutions is that obviously we should not use a mixture stronger than necessary, but the saving in cost per tree is so low that a good margin of safety should be provided.

You will note that Mr. Gibson again reports failure with all of the water emulsion carriers tested. Personally, I feel that these emulsions offer the greatest possibility of reducing the cost of this method of treatment. But until additional promising leads are suggested, I can see no advantage in further experimentation with the substances already used.

I am sure Mr. Gibson would appreciate your comments and suggestions in connection with this report.

Copies of this letter and the report are being sent to Keen, Furnish, Wygant, and Whitten.

James C. Evenden

Enclosure

SPRING CONTROL OF THE MOUNTAIN
PINE BEETLE IN WESTERN WHITE PINE
WITH PENETRATING SPRAYS
1942

INTRODUCTION

Previous experiments and control projects have shown the effectiveness of penetrating sprays in controlling the mountain pine beetle in western white pine. Although effective, the somewhat high cost of these sprays has made it necessary to conduct further studies for the purpose of developing cheaper sprays. Use of water instead of oil as the carrier of the lethal agent has offered the possibility of such drastic cost reductions that tests with promising emulsions were also desirable. With the preceding objectives in view, further experiments with penetrating sprays were initiated in the spring of 1942.

MATERIALS AND METHOD

Initially it was planned to treat fourteen logs with each spray. Seven were to contain immature brood and an equal number mature brood. It was soon found however that too few logs containing immature brood were available. For that reason spraying was confined, for most of the tests, to logs containing brood in the more advanced stages of development - large larvae, pupae and new adults.

Material for the tests consisted of logs four feet long selected from trees which were found at the time of felling to have adequate brood on all sides. To furnish a more representative sample, logs were used from various parts of two or more trees for each test. When treated, the spray was applied to the bark until the surface was saturated and the liquid was ready to run. All sides of the log were similarly treated. In this manner about 100 square feet of bark surface were treated per gallon of spray and may be considered as the quantity necessary to produce a saturated condition of the bark surface. Logs to be treated while wet were given the same degree of treatment with water prior to spraying with the oil-base formulae.

Except when likely to be exposed to sunlight, with the consequent possibility of solar killing, treated logs were left where sprayed. This was for the purpose of duplicating conditions on a control job.

Unusually wet weather during the latter half of May, when the experiments were being conducted, led the writer to partially duplicate most of the experiments during June. The purpose was to determine if

treatments under the less moist conditions of June would give better control than the same spray applied in May.

The emulsions tested were five selected from 20 tested for properties of ease of mixing, stability of emulsion, rapidity of spread and degree of absorption.

EXAMINATIONS

Initial examinations of treated material to determine effectiveness of the sprays were made in early July, but it was quickly seen that the brood had made slower than normal development and that further normal as well as spray-induced mortality could be expected. Examinations were repeated in mid-July and as often thereafter until August 18 as the condition of brood in the logs demanded.

In making the examinations no attempt was made to count brood killed by the chemical, only data concerning the living being recorded as to number, their developmental status and the size of the area examined. Where more than an average of two living insects per square foot of bark surface were found, the log was reexamined at a later date on the theory that normal mortality and delayed effect of the chemical might further reduce the number of survivors.

Two living insects per square foot were arbitrarily set as the maximum acceptable survival per square foot of bark surface treated with penetrating sprays.

Data concerning the sprays and the examinations are presented in the following pages:

Formula	Diesel oil	4
	Orthene	1

This spray was used merely as a basis of comparison for previous work to reveal any unusual conditions that might develop. That none did develop was indicated by the complete control obtained with the formula. The data are shown in table 1.

Table 1 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

		Formula		Diesel oil		4 $\frac{1}{2}$				
				Orthene $\frac{2}{1}$		1				
Date	Number of	Living brood						Sq. ft.	Date	
<u>exam.</u>	<u>Tree</u>	<u>Log</u>	<u>Lar.</u>	<u>Pup.</u>	<u>N.A.</u>	<u>N.A.E.H.</u>	<u>5/</u>	<u>Total</u>	<u>exam.</u>	<u>treated</u>
7-7	41	1	--	--	--	--	--	--	2.0	5-30
"		3	--	--	--	--	--	--	4.0	"
"		5	--	--	--	--	--	--	3.0	"
"		7	--	--	--	--	--	--	5.0	"
Aver. date										
exam. 7-7			--	--	--	--	--	--	14.0	"

1/ Ratio of Diesel oil to lethal agent
 2/ Orthodichlorobenzene
 3/ New adult emergence holes

Formula Diesel oil 6
 Orthene 1

This spray proved highly effective. The only survivors at the time of examination were a few larvae which even in untreated material would be subject to further mortality during the time they would be developing into pupae and new adults prior to emergence. With more mortality due to the spray to be expected, final control would be almost perfect. The data are shown in table 2.

From studies by W. D. Bedard and T.T. Torrell ^{1/} it has been learned that about 58 percent normal mortality may be expected between the mature larval stages and emergence and 24 percent between the pupal stage and emergence.

1/ A method for predicting the trend of mountain pine beetle infestations in western white pine - Forest Insect Laboratory - Coeur d'Alene, Idaho - 1939

Table 2 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

		Formula		Diesel oil		Orthene		6	1
Date exam.	Number of Tree	Log	Living brood					Sq. ft. exam.	Date treated
			Lar.	Pup.	N.A.	N.A.E.H.	Total		
7-7	36	4	4	--	--	--	4	4.0	5-19
7-10	24	3	--	--	--	--	--	5.0	"
"		6	--	--	--	--	--	4.0	"
7-21	36	1	1	--	--	--	1	6.0	"
7-23	48	1	--	--	--	--	--	4.0	6-8
"		2	--	--	--	--	--	3.5	"
"	49	1	--	--	--	--	--	2.0	"
"		2	1	--	--	--	1	7.0	"
Aver. date exam. 7-18			6				6	35.5	

$$6 \div 35.5 = .17 \text{ living per sq. ft.}$$

Formula

Diesel oil
Orthene8
1

Effectiveness of this spray was of a high degree. Survival in one tree was above the arbitrary limit of 2 per square foot considered acceptable, but the living brood was found under bark which was green at the time it was treated. Apparently this green bark was already so saturated with moisture that it could not absorb any of the spray. This conclusion is based on observations of nearby bark areas, not green, which showed complete control and an odor of the spray. No odor of spray could be noted on the bark which had been green when treated. The data are shown in table 3.

Table 3 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

		Formula		Diesel oil		Orthene		8	
								1	
Date exam.	Number of	Living brood						Sq. ft.	Date
	Tree	Log	Lar.	Pup.	N.A.	N.A.E.H.	Total	exam.	treated
7-7	36	2	--	--	--	--	--	3.5	5-19-42
"	"	6	--	--	--	--	--	3.5	"
7-10	32	1	5	--	--	--	5	4.0	"
"	24	1	--	--	--	--	--	4.0	"
"	"	4	--	--	1	--	1	6.0	"
"	"	5	--	--	--	--	--	4.0	"
7-30	"	8	5	1	5	--	11	3.5	"
Aver. date exam.	7-12		10	1	6	--	17	28.5	

$$17 \div 28.5 = .6 \text{ living per sq. ft.}$$

7-23	54	2	1	--	--	--	1	6.0	6-12-42
"	"	5	--	--	--	--	--	3.5	
"	"	6	--	--	--	--	--	3.0	
"	55	1	--	--	--	--	--	1.5	
Aver. date exam. 7-23			1	--	--	--	1	14.0	

$$1 \div 14 = .07 \text{ living per sq. ft.}$$

Average of tests on two different dates = .42 living per sq. ft.

Formula	Diesel oil	10
	Orthene	1

These logs were first sprayed with water until the bark surface was saturated, followed by a similar treatment with the oil-base spray. The objective in the preliminary treatment with water was to duplicate as nearly as possible field conditions following heavy, driving rains. Average control obtained under the conditions of this experiment was insufficient to be acceptable, although some logs showed high mortality. Apparently a water-saturated bark surface prevents the absorption of sufficient lethal ingredient of the spray to effect control of the underlying brood. The same and even weaker sprays gave excellent control of the brood in dry logs. We feel justified, therefore, in believing that under severe wetting conditions this spray will not give consistently acceptable control even though occasional logs show no surviving insects. The data are shown in table 4.

Table 4 - Wet logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

				Formula	Diesel oil	10			
					Orthene	1			
Date exam.	Number of Tree	Log	Living brood				Sq. ft. exam.	Date treated	
			Lar.	Pup.	N.A.	N.A.M.H.	Total		
7-10	44	1	--	--	--	--	--	2.5	6-3
8-4	43	5	3	3	15	2	23	2.0	"
"		3	--	--	39	28	67	2.0	"
8-5	41	2	1	13	14	--	28	2.0	"
"		4	9	4	11	--	24	3.0	"
"		6	2	--	--	--	2	3.0	"
"	44	7	3	--	4	1	8	1.0	"
8-4	42	1	7	2	15	--	24	2.0	6-4
"		2	11	7	28	--	46	1.0	"
Aver. date exam. 8-2			36	29	126	31	222	28.0	

$$222 \div 28.0 = 8.0 \text{ living per sq. ft.}$$

7-23	50	3	--	--	--	--	--	5.0	6-12
"		6	--	--	--	--	--	4.5	"
Aver. date exam. 7-23			--	--	--	--	--	9.5	

Average of tests on two different dates $222 \div 37.5 = 5.9$ living per sq. ft.

Formula

Diesel oil
Orthene10
1

Although the average survival for the logs treated in May is somewhat greater with this spray than with those having orthene in greater concentration, attention is called to the high percent larvae and pupae are of the total survivors. These would undoubtedly be decidedly decreased by normal mortality as well as by delayed action of the spray.

Logs treated in mid-June showed complete control. An average of the two treatments shows a survival of about .7 insects per square foot - satisfactory control for this low concentration spray. Table 5 contains the data.

Table 5 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

		Formula		Diesel oil		10			
				Orthene		1			
Date exam.	Number of	Living brood						Sq. ft.	Date
	Tree	Log	Lar.	Pup.	N.A.	N.A.N.H.	Total	exam.	treated
7-9	38	2	2	2	--	--	4	5.0	5-22
"	"	4	--	--	--	--	--	4.0	"
7-10	32	2	--	--	--	--	--	4.0	"
"	"	4	3	--	--	--	3	5.0	"
7-20	38	8	2	--	--	--	2	6.0	"
8-4	"	6	3	7	7	--	17	2.5	"
"	"	10	--	--	2	--	2	2.5	"
Aver. date exam.	7-21		10	9	9		28	27.0	

$$28 \div 27.0 = 1.04 \text{ living per sq. ft.}$$

7-23	56	4	--	--	--	--	--	3.0	6-12
"	"	6	--	--	--	--	--	3.0	"
"	"	8	--	--	--	--	--	3.5	"
"	57	2	--	--	--	--	--	3.0	"
Aver. date exam.	7-23		--	--	--	--	--	12.5	

Average of tests on two different dates

$$28 \div 39.5 \text{ sq. ft.} = .71 \text{ living brood per sq. ft.}$$

Diesel oil	12
Orthene	1

This formula gave excellent results in spite of a weak concentration. Survival was light and uniformly low wherever any was noted. Apparently this formula is as effective as the 10 to 1 mixture of the same materials.

Table 6 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

Diesel oil	12
Orthene	1

Date exam.	Number of		Living brood					Sq. ft. exam.	Date treated
	Tree	Log	Lar.	Pup.	N.A.	N.A.E.H.	Total		
7-9	31	4	1	--	--	--	1	5.0	5-28-42
"	"	6	--	--	--	--	--	4.0	"
"	38	3	--	--	--	--	--	5.0	"
7-20	"	5	--	1	--	--	1	4.0	"
"	"	11	1	--	--	--	1	5.0	"
7-30	31	1	1	4	1	--	6	5.0	"
8-4	38	9	1	2	1	--	4	2.5	"
Aver. date exam. 7-22			4	7	2	--	13	30.5	

$$13 \div 30.5 = .42 \text{ living per sq. ft.}$$

7-23	54	1	--	--	--	--	4.5	6-12
"	"	3	--	--	--	--	6.0	"
"	57	7	--	--	--	--	2.0	"
8-17	"	5	2	1	--	3	6.0	"
Aver. date								
exam. 7-29		2	1	--	--	3	18.5	

$$3 \div 18.5 = .16 \text{ living per sq. ft.}$$

For both times of treating the average was $16 \div 49.0 = .33$ living per sq. ft.

Formula	Diesel oil	15
	Orthene	1

This spray gave excellent results on all logs treated on May 28 and on the two treated on June 8. Two sprayed on June 12 showed acceptable control on one log but too high a survival on the other. No definite reason for the difference was apparent. However, it is possible this spray is effective wherever the conditions are favorable, but is of too weak concentration to assure effective control where they are unfavorable. Data are shown in table 7.

Table 7 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

		Formula		Diesel oil 15					
				Orthene 1					
Date exam.	Number of		Living brood					Sq. ft. exam.	Date treated
	Tree	Log	Lar.	Pup.	N.A.	N.A.E.H.	Total		
7-9	31	2	--	--	--	--	--	5.0	5-28
"		3	2	--	--	--	2	5.0	"
"		5	--	1	--	--	1	5.0	"
7-20	38	1	--	--	--	--	--	6.0	"
"	31	9	--	--	--	--	--	5.0	"
"	31	10	--	--	--	--	--	4.0	"
8-7	38	7	--	--	1	--	1	3.0	"
Aver. date									
exam. 7-18			2	1	1	--	4	33.0	"

$$4 \div 33.0 = .12 \text{ living per sq. ft.}$$

7-23	50	1	--	--	--	--	--	6.0	6-8
"		4	--	--	--	--	--	5.0	"
8-17	57	4	3	5	7	--	15	4.5	6-12
"		6	2	2	--	--	4	4.0	"
Aver. date exam. 8-5			5	7	7		19	19.5	

$$19 \div 19.5 = .97 \text{ living per sq. ft.}$$

Average of treatments on three different dates =

$$23 \div 52.5 = .44 \text{ living per sq. ft.}$$

Diesel oil	8
Naphthalene in orthene	1

This spray gave excellent results. The .60 living per square foot of bark surface at the time of examination were all larvae and pupae of which a high mortality could be expected prior to emergence. The data are shown in table 8.

Table 6 - Logs treated in the spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

Diesel oil	8
Naphthalene in orthene	1

Date exam.	Number of		Living brood				Sq. ft. exam.	Date treated	
	Tree	log	Lar.	Pup.	N.A.	N.A.E.H.			Total
7-8	40	1	12	3	--	--	15	10.0	5-29
"		3	3	1	--	--	4	5.0	"
"		9	--	--	--	--	--	3.0	"
7-30	34	2	1	--	--	--	1	3.0	"
Aver. date exam.	7-13		16	4	--	--	20	21.0	

$$20 \div 21.0 = .95 \text{ living per sq. ft.}$$

7-23	28	4	--	--	--	--	3.0	6-6
"		5	--	1	--	1	3.0	"
8-4	37	3	--	--	--	--	4.0	"
7-23		4	--	--	--	--	2.5	"
"		7	--	--	--	--	2.0	"
Aver. date								
exam. 7-25			--	1	--	1	14.5	

$$1 \div 14.5 = .07 \text{ living per sq. ft.}$$

Average of two treatments = $21 \div 35.5 = .60$ living per sq. ft.

Diesel oil	10
Naphthalene in orthene	1

Control secured on the series of logs treated on May 29 was excellent. Equally good results were obtained from two of the four logs sprayed on June 4, but on the other two logs there was considerable survival. On one of the latter logs a sour-sap condition prevailed in the area sampled; on the second the only remaining bark sample was near the end of the log, where no attempt is made to treat as thoroughly as on the main part. This is due to the proximity of the ends of other logs of the same tree which are treated with different sprays, where thorough spraying to the ends of the logs may result in sufficient splashing to overlap treatments, with consequent confusing results. In spite of the unfavorable data from these two logs the average survival was so low the control is considered acceptable. The data are presented in table 9.

Table 9 - Logs treated in the spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

Formula		Diesel oil		Naphthalene in orthene		10	1		
Date exam.	Number of Tree	Log	Living brood				Sq. ft. exam.	Date treated	
			Lar.	Pup.	N.A.	N.A.E.H.	Total		
7-8	40	2	1	--	--	--	1	5.0	5-29
"		4	2	--	--	--	2	6.0	"
"		6	5	--	--	--	5	4.0	"
"		7	1	--	--	--	1	4.0	"
"		8	1	--	--	--	1	4.0	"
7-10	34	4	--	--	--	--	--	5.0	"
		1	3	--	--	--	3	3.0	"
Aver. date exam. 7-8			13	--	--	--	13	31.0	

$$13 \div 31.0 = .42 \text{ living per sq. ft.}$$

7-10	44	2	--	3	--	3	5.0	6-4
7-21	45	2	--	--	2	2	8.0	
8-4	44	4	--	--	4	6	.4	2/
"		6	1	--	3	5	1.0	<u>2/</u>
Aver. date								
exam. 7-25		1		3	9	3	16	14.4

$$16 \div 14.4 = 1.11 \text{ living per sq. ft.}$$

Average of both series = $29 \div 45.4 = .64$ living per sq. ft.

- 1/ At rate of 3 lbs. per gallon of orthene.
2/ Samples not considered typical because from only remaining bark surface near end of one log and where sour-sap condition existed in the other.

Formula

Diesel oil

10

Naphthalene in orthene 1

Results from these two tests indicate quite clearly that this spray does not give consistently effective control of brood in logs that are wet at the time they are treated. On some logs, complete or at least acceptable control may result, but on others the survival may be so light as to leave a question in the mind if any control had been secured.

Judging by the presence or absence of odor of spray, absorption on the wet logs was quite irregular. On some parts of the bark surface, where the odor was strong, absorption had apparently been good because control was excellent; where there was little or no odor the survival was high. This variation in odor and survival is quite puzzling because the writer believed both wet condition and spray application were quite uniform. It is possibly due to two factors: variation in amount of absorption of the liquids by the bark and to differences in evaporation. The data are presented in table 10.

Table 10 - Wet logs treated in the spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

Formula		Diesel oil		10			
		Naphthalene in orthene		1			
Date exam.	Number of Tree	Log	Living brood		Sq. ft. exam.	Date treated	
			Lar.	Pup.	N.A. N.A.E.H. Total		
7-21	45	1	--	1	-- -- 1	6.0	5-30
"	46	1	--	--	-- -- --	7.0	"
"	"	3	--	--	-- -- --	2.5	"
8-4	44	3	--	--	2 -- 2	.2	"
"	45	3	--	--	2 10 12	1.0	"
"	43	2	1	--	31 1 33	2.0	"
"	"	4	2	2	25 5 34	2.5	"
"	"	6	--	1	5 -- 6	1.0	"
"	44	5	--	--	5 -- 5	1.0	"
Aver. date exam. 7-30			3	4	70 16 93	23.2	

$$83 \div 23.2 = 3.58 \text{ living per sq. ft.}$$

8-4	50	2	--	--	--	--	6.0	6-8
"		5	--	--	--	--	5.0	"
			--	--	--	--	11.0	

No survivors.

$$\text{Average of two series} = 93 \div 34.2 = 2.72 \text{ living per sq. ft.}$$

Formula	Diesel oil	12
	Naphthalene in orthene	1

This spray gave excellent results. As the surviving brood noted was 80 percent larvae and pupae and thus subject to even further high normal as well as spray-induced mortality, it can be readily seen that emergence would at most be very low and possibly none would occur. The data are shown in table 11.

Table 11 - Logs treated in the spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

		Formula		Diesel oil		12			
				Naphthalene in orthene		1			
Date exam.	Number of		Living brood					Sq. ft. exam.	Date treated
	Tree	Log	Lar.	Pup.	N.A.	N.A.E.H.	Total		
7-9	31	7	--	--	--	--	--	4.0	5-29
"	39	6	--	--	--	--	--	5.0	"
7-10	33	2	3	--	--	--	3	4.0	"
"	32	3	3	2	--	--	5	2.5	"
7-20	39	1	4	--	--	--	4	6.0	"
"	"	3	--	--	--	--	--	7.0	"
8-4	31	8	3	1	2	--	6	4.0	"
Aver. date exam. 7-16			13	3	2	--	18	32.5	"

$$18 \div 32.5 = .52 \text{ living per sq. ft.}$$

7-23	37	2	--	--	--	--	--	2.5	6-6
"	"	6	--	--	--	--	--	2.0	"
"	28	1	--	--	--	--	--	3.5	"
"	"	3	--	--	2	--	2	3.0	"
Aver. date exam. 7-23			--	--	2	--	2	11.0	

$$2 \div 11.0 = .18 \text{ living per sq. ft.}$$

$$\text{Average for two periods} = 20 \div 43.5 = .46 \text{ living per sq. ft.}$$

Formula	Diesel oil	15
	Naphthalene in orthene	1

Although the figures indicate a somewhat high average survival of over one living insect per square foot for the series of trees treated on May 28, it must be pointed out that all the living brood were in the larval and pupal stages. They are subject to high normal mortality, as well as possible further control from the spray. Furthermore, over 40 percent of the survivors were on one log in a narrow strip which gave no spray odor. For the above reasons this formula may be considered as highly effective. The data are presented in table 12.

Table 12 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

				Formula		Diesel oil		15	
						Naphthalene in orthane		1	
Date exam.	Number of		Living brood					Sq. ft.	Date
	Tree	Log	Lar.	Pup.	N.A.	N.A.M.H.	Total	exam.	treated
7-9	39	2	1	--	--	--	1	6.0	5-28
"	"	7	2	--	--	--	2	3.0	"
7-10	33	1	3	--	--	--	3	5.0	"
"	3	3	3	2	--	--	5	5.0	"
8-4	34	5	8	2	--	--	10	4.0	"
"	"	6	--	--	--	--	--	4.0	"
"	39	4	4	11	--	--	15	3.5	"
Aver. date exam. 7-20			21	15	--	--	36	30.5	"

$$36 \div 30.5 = 1.18 \text{ living per sq. ft.}$$

7-23	37	1	--	--	1	--	1	3.0	6-6
"		5	--	--	--	--	--	2.5	"
"	28	2	--	--	--	--	--	3.0	"
"		6	--	--	--	--	--	1.0	"
Aver. date exam. 7-23			--	--	1	--	1	9.5	

$$1 \div 9.5 = .10 \text{ living per sq. ft.}$$

$$\text{Average of two periods} = 37 \div 40 = .90 \text{ living per sq. ft.}$$

Formula	Diesel oil	10
	Trichlorobenzene	1

The high degree of effectiveness of the spray is indicated by the light survival. As the latter are chiefly larvae, subject to high mortality and possibly more control from the spray, the final result may be nearly 100 percent control. The data are given in table 13.

Table 13 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

		Formula		Diesel oil		10		
				Trichlorobenzene		1		
Date exam.	Number of	Living brood					Sq. ft.	Date
	Tree	Log	Lar.	Pup.	N.A.	N.A.E.H.	exam.	treated
7-23	56	1	--	--	--	--	4.5	6-13
"		2	2	--	--	--	3.0	"
"		3	1	1	1	--	5.0	"
"		5	--	--	--	--	3.5	"
"		7	--	--	--	--	3.0	"
"	57	1	6	--	--	--	2.5	"
"		3	--	--	--	--	3.0	"
Aver. date exam. 7-23			9	1	1	--	24.5	

$$11 \div 24.5 = .45 \text{ living per sq. ft.}$$

Formula	Diesel oil	15
	Trichlorobenzene	1

Control with this spray is still well within acceptable limits but considerably higher than with the 10 to 1 mixture of the same ingredients. The presence of a high ratio of new adults to the total brood may not be significant but at the same time does seem to show that the spray is sufficiently low in lethal concentration to permit the maturing of resistant insects. The data are given in table 14.

Table 14 - Logs treated in spring of 1942 with penetrating sprays - Coeur d'Alene National Forest

Formula				Diesel oil Trichlorobenzene			15 1		
Date exam.	Number of		Living brood					Sq. ft.	Date
	Tree	Log	Lar.	Pup.	N.A.	N.A.N.H.	Total	exam.	treated
7-23	56	9	--	2	3	--	5	4.0	6-13
8-4	"	11	--	1	1	--	2	3.0	"
"	27	1	1	--	7	4	12	7.0	"
"	"	3	--	--	--	--	--	4.5	"
"	"	5	--	--	1	--	1	4.0	"
Aver. date exam. 8-2			1	3	12	4	20	22.5	

$$20 \div 22.5 = .90 \text{ living per sq. ft.}$$

Material, method of treatment, and examinations were the same as for the oil-base sprays. Complete control on some logs was often in contrast to no evidence of spray-caused mortality on others; results too variable to warrant further consideration of these sprays.

In spite of the disappointing results with emulsions it is felt that further tests should be made whenever promising formulae are developed. The possibility of such drastic savings as can be obtained by the use of water instead of Diesel oil as the carrier justifies this further research. At present 80 percent of the spray used is the carrier, Diesel oil. Success with sprays of lower concentration will increase this percentage. All spray materials must now be transported more or less long distances to the project, involving considerable expense. Substitution of water, usually closely available, would mean decided savings in truck and pack stock transportation as well as some man-power.

DISCUSSION OF OIL-BASE PENETRATING SPRAYS

There seems to be little to choose as to effectiveness between the three series of oil-base sprays tested. The series in which naphthalene in orthene is the lethal agent showed the highest average survival in three of the four tests on dry logs, as may be seen in table 16. However, it must be pointed out that in these tests there was a much larger ratio of surviving larvae and pupae to total brood than in logs where orthene is the lethal agent. As has been previously pointed out, larvae and pupae are subject to a high normal mortality as well as to a longer exposure to further control by the chemical than are callow adults. Therefore, we may consider that final survival would show little difference in effectiveness of these two series of sprays. With no difference in effectiveness, choice would be based on cost. On the latter basis the sprays containing naphthalene would be eliminated because more labor is required to prepare sprays with it as an ingredient than for those containing only orthodichlorobenzene.

With trichlorobenzene as the lethal agent, the best results of the three series were shown for the 10 to 1 mixture, but the 15 to 1 spray was the poorest of the three. However, the differences were insufficient to be considered significant, in which case sprays containing trichlorobenzene may be considered as equalling those containing orthodichlorobenzene in effectiveness. As the price of the two chemicals was about the same in the spring of 1942, either could be used.

For wet logs the control was insufficient with the two sprays tested. Satisfactory control with 4 to 1 oil-orthene spray and insufficient mortality from 10 to 1 mixtures of the same ingredients indicates that the limit of effective control lies between these two.

In spite of apparently more difficult conditions to overcome, as good control was obtained against immature as against mature brood. The reason for this is not known, but it is suggested that it may have been due to exposure to the spray for the longer developmental period in the case of immature brood. The longer exposure may have compensated for possibly less absorption by wetter bark and be responsible for the excellent results.

BROOD IN TREATED AND UNTREATED MATERIAL

It has been previously stated in this report that acceptable survival in treated material has been limited to a maximum of not over two living insects per square foot of bark surface. This figure, however, gives no indication of the degree of control secured. To give some index of the latter, two sets of data were obtained. In the first set, emergence from infested material was trapped in and collected from large galvanized iron cans. Average emergence from this material is shown in table 16. The number emerging is believed to have been higher than average. This is believed to be due at least in part to the protection afforded the developing brood from parasites and predators during the period the developing brood was in the can.

The second approach to the problem of emergence was by means of Buckhorn type cages each of about 6 square-foot bark surface, placed on infested trees on the section from 2 to 6 feet above the ground. Emergence from these cages was quite variable not only between trees but between cages on opposite sides of the same tree. It is also possible that emergence was not complete from these cages by the end of October 1942. These data too are given in table 16.

Inspection of the data for survivors from the 12 to 1 spray containing Diesel oil and orthodichlorobenzene reveals .33 living per square foot of bark surface at the time of examination. Comparing that figure with the 97.1 per square foot from galvanized iron cans shows an average of .4 percent survival. Compared with the average data from the Buckhorn cages, survival of .33 per square foot is less than 2 percent. By either comparison the effectiveness of the spray is quite high.

Table 16 - Summary of results of tests with oil-base sprays conducted
in spring of 1942 - Coeur d'Alene National Forest

Ratio of Diesel oil to lethal agent	Data from treatments with sprays consisting of Diesel oil and														
	Orthodichlorobenzene					Naphthalene in Orthene					Trichlorobenzene				
	Survivors per sq. ft.					Survivors per sq. ft.					Survivors per sq. ft.				
	Lar.	Pup.	N.A.	N.A.E.H.	Total	Lar.	Pup.	N.A.	N.A.E.H.	Total	Lar.	Pup.	N.A.	N.A.E.H.	Total
20 to 1	--	--	--	--	--	--	--	--	--	--	.14	.00	1.00	.33	1.47
15 to 1	.13	.15	.16	--	.44	.51	.37	.02	--	.90	.04	.13	.54	.18	.89
12 to 1	.12	.17	.04	--	.33	.30	.07	.09	--	.46	--	--	--	--	--
10 to 1	.25	.23	.23	--	.71	.31	.06	.20	.07	.64	.37	.04	.04	--	.45
10 to 1 (wet logs)	.96	.77	3.36	.83	5.92	.09	.12	2.04	.47	2.72	--	--	--	--	--
8 to 1	.26	.02	.14	--	.42	.46	.14	--	--	.60	--	--	--	--	--
6 to 1	.17	--	--	--	.17	--	--	--	--	--	--	--	--	--	--
4 to 1	.00	--	--	--	.00	--	--	--	--	--	--	--	--	--	--

Untreated - Emergence of new adults from G.I. cans --- 97.1 Sq. ft. exam.
45.0

Emergence of Mountain Pine Beetle from
Western White Pine as Indicated by Buckhorn Cages
1942

Tree number	<u>1</u>	<u>2</u>	<u>3 1/2</u>	<u>4 1/2</u>
Cage number	1	2	3 4	5 6
Brood emergence per square foot	11.3	3.0	31.8 33.2	16.8 8.2

Average emergence from six cages = 17.3 per sq. ft.

1/ Two cages on each of trees 3 and 4.

RECOMMENDATIONS

The tests of lower concentrations of lethal agent in Diesel-oil carrier conducted in the spring of 1942 shows that a mixture of orthene in oil of 1 part to 12 gives excellent control. Acceptable results were obtained with a 1 to 15 concentration, but considerable survival in one log is thought to indicate too weak a mixture to overcome adverse conditions. Therefore the 1 to 12 mixture of orthene in Diesel oil is recommended for future spring control projects against the mountain pine beetle in western white pine.

A close similarity in control results between the orthene-Diesel-oil sprays and those containing trichlorobenzene as the lethal agent indicate that the latter is just as effective as the former. The writer feels, however, that more experience with the latter sprays is needed before giving them an unqualified recommendation. Tests with 10 to 1, 12 to 1 and 15 to 1 mixtures are suggested for the spring of 1943.

In comparing results, no advantage was apparent by adding naphthalene to orthene to comprise the lethal agent in mixtures of the former with Diesel oil. Therefore, no further tests with these sprays are planned.

The emulsions tested failed to give encouraging results, precluding justification for any further tests with them. However, emulsions offer such an excellent chance to reduce control costs that it is suggested a search be made for and tests conducted with any that seem promising.

SUMMARY

In the search for cheaper and more effective sprays to control the mountain pine beetle in western white pine, four series of tests were conducted in the spring of 1942. They included sprays whose lethal agent consisted of one of the following materials:

- (1) orthodichlorobenzene
- (2) naphthalene dissolved in orthodichlorobenzene
- (3) trichlorobenzene
- (4) orthodichlorobenzene and emulsifying agents

The lethal agent was added to various amounts of Diesel oil in the first three series of tests and to water in the fourth. On the basis of consistent control, cost, and previous experience, the orthene-Diesel-oil mixture in ratio of 1 to 12 parts gave the most acceptable results. The extra labor involved in dissolving naphthalene in orthene makes the second series less economical, although it was about equally effective. Trichlorobenzene gave excellent results in two of the tests, but more experience with it is desired before giving it an unqualified recommendation. The use of a 1 to 12 mixture of orthene in Diesel oil is recommended for spring control of the mountain pine beetle in western white pine. The emulsions tested were ineffective. Further tests with both oil-base sprays and emulsions are also suggested.

A 10 to 1 mixture of Diesel-oil-orthene and Diesel-oil-naphthalene in orthene failed to give acceptable control in logs whose bark surface was wet at the time of spraying. The most dilute effective spray lies between 4 to 1 and 10 to 1, the former having proved effective in fall control experiments.